RESONATOR FOR ACTIVE NOISE ATTENUATION SYSTEM

RELATED APPLICATION

This application claims priority to provisional application 60/205,731 filed on May 19, 2000.

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates to a resonator that works in conjunction with an active noise cancellation module to reduce low frequency engine noises.

2. Related Art.

Internal combustion engines include air induction systems for conducting air to engine cylinders. Engine noise is propagated through the air induction systems, which is undesirable. Noise attenuation mechanisms have been installed within the air induction systems to reduce these noises. For this application, this noise attenuation mechanism is referred to as an Active Noise Cancellation (ANC) system and includes a speaker, a microphone, and a signal generator that are mounted within an air inlet duct housing. The microphone detects the noise and generates a noise signal that is sent to the signal generator. The signal generator phase-shifts the signal and sends the signal to the speaker to generate a sound field that cancels out the noise that is being detected by the microphone.

High power requirements and large speaker sizes are required to reduce engine noise levels below accepted values. Typically, engine noise must be reduced below 110 Hertz (Hz). This causes the ANC system to be very large, taking up a

considerable amount of packaging space. Additionally, these ANC systems draw a large amount of power from the vehicle electrical system in order to effectively cancel the high levels of low frequency noise.

It is the object of the present invention to provide an ANC system that overcomes the deficiencies outlined above.

SUMMARY OF THE INVENTION

In a disclosed embodiment of this invention, an active noise attenuation system includes an air inlet duct housing having an inlet end into which air is drawn and an outlet end operably connected to an engine. The system also includes a sound detector and a speaker assembly. A resonator is supported by the housing and is positioned between the speaker and the engine. The resonator attenuates a portion of the low frequency noise. A controller receives and phase shifts a noise signal generated by the sound detector that corresponds to the attenuated engine noise. The signal is sent to the speaker to generate a sound field to attenuate the remaining engine noise.

The engine generates low frequency noise that has a noise profile with a peak noise. In a preferred embodiment, the resonator attenuates the peak noise resulting in an attenuated engine noise level. The sound detector senses the attenuated engine noise level and the speaker produces a sound field that cancels or reduces the noise level.

An air filter is installed within the housing behind the speaker to filter out contaminates from the air flowing through the housing. In one embodiment, a resonator is mounted to the filter. The filter is cylindrically shaped with a first end

fitting over the resonator and a second end fitting over the outlet end of the housing. In another embodiment, the resonator extends radially outwardly from the housing between the filter and the engine.

The subject apparatus provides an ANC system that significantly reduces low frequency engine noise by utilizing smaller speakers and less vehicle electrical power.

These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a prior art ANC system.

Figure 2 is a schematic diagram of one embodiment of an ANC system incorporating the subject invention.

Figure 3 is a schematic diagram of an alternate embodiment of an ANC system.

Figure 4 is a graph of Attenuation dB versus Frequency.

DETAILED DESCRIPTION OF AN EXEMPLARY EMBODIMENT

Referring to the drawings, Figure 1 shows a known noise attenuation system 10 including an air inlet duct housing 12 forming part of an air induction system for an internal combustion engine 14. The air inlet duct housing 12 has an inlet end 16 and an outlet end 18 that is operably connected to the engine 14. Typically the inlet end 16 is of greater diameter than the outlet end 18.

A speaker assembly 20 is mounted within the air inlet duct housing 12 to face the inlet 16. A sound detector 22, such as a microphone, is mounted in front of the speaker 20 to detect engine noise. The microphone 22 generates a noise signal 24 that corresponds to the detected noise. The signal 24 is sent to a controller, microprocessor, or other similar device 26 where the signal is phase-shifted. Preferably, the signal 24 is phase-shifted 180 degrees and is then sent to the speaker 20. The speaker 20 generates a sound field based on the phase-shifted signal to cancel out the detected engine noise. The operation of the microphone 22, speaker 20, and controller are well known and will not be discussed in detail.

An air filter 28 is mounted within the housing 12 between the inlet 16 and outlet 18 for filtering contaminants from the air as it flows through the housing 12. The subject invention utilizes a resonator 30, shown in Figure 2, that is supported by the housing 12 and is preferably positioned between the speaker 20 and the engine 14 for attenuating engine noise. The engine 14 generates an undesirable low frequency noise that has a noise profile defining a peak noise. The resonator 30 attenuates the peak noise over a predetermined range, resulting in an attenuated low frequency engine noise. The microphone 22 senses the attenuated low frequency engine noise and generates the signal 24, which represents an attenuated low frequency engine noise. As discussed above, the controller 26 receives the attenuated signal 24, phase-shifts the signal 24, and sends a control signal 32 to the speaker to generate a sound field that attenuates or cancels the remaining engine noise.

Any type of resonator 30 known in the art can be used to attenuate the peak engine noise. A resonator 30 is typically a hollow chamber or cavity with dimensions chosen to permit internal resonant oscillation of acoustical waves of specific frequencies. Thus, the size and shape of the resonator 30 will vary depending on the specific application. The size and shape can be change to allow attenuation of predetermined frequencies for different engines.

The resonator 30 can be situated either inside or outside the ANC unit to suit the required packaging of the system. In one embodiment, shown in Figure 2, the resonator 30 extends radially outward from an external surface 34 of the housing 12. The resonator 30 can be integrally formed with the housing 12 or can be supported on an arm 36. The resonator 30 is preferably positioned on the housing 12 behind the air filter 28.

In another embodiment, shown in Figure 3, the resonator 30 is supported by the air filter 28 within the housing 12. The air filter 28 is preferably cylindrical in shape and has a first end 40 that fits over the resonator 30 and a second end 42 that fits over the air outlet 18 to the engine 14. This both connects the resonator 30 into the ANC system and also locates and supports the filter 28. Thus, the filter 28 does not require a fully sealed end, which reduces filter weight and cost.

The design of the resonator 30 is a Helmholtz configuration that permits high attenuation over a narrow noise band. The resonator's amplitude of attenuation does not require it to remove all the noise at the required frequency range, but to reduce the

noise such that the ANC unit can then add some small contribution to tailor the noise to the required frequency content.

An Attenuation decibel (dB) versus Frequency Hertz (Hz) for a preferred embodiment of the resonator 30 is shown in Figure 4. The engine noise has a profile 48 that has a peak range of noise indicated generally at 50. The resonator 30 is tuned to attenuate this peak range of noise 50. Typically, the resonator 30 is tuned to attenuate within the range of 60-90 Hz, resulting in an attenuated profile 52. This allows the size of the ANC speaker 20 to be reduced to improve packaging, reduce cost, and reduce amplifier power requirements. Speakers 20 that are less than 400 millimeters in diameter can be used with an ANC system incorporating the subject resonator 30, which can significantly increase packaging space for other vehicle components.

Although a preferred embodiment of this invention has been disclosed, it should be understood that a worker of ordinary skill in the art would recognize many modifications come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.